State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
PROJECT OPERATIONS INFLUENCING FISH HABITAT AND WATER QUALITY IN THE THERMALITO DIVERSION POOL AND THE THERMALITO FOREBAY
SP-F3.1, TASKS 3B AND 3C

Oroville Facilities Relicensing
FERC Project No. 2100

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REPORT SUMMARY

The objective of Task 3B was to generally describe the fish habitat in the Thermalito Diversion Pool and Thermalito Forebay. The physical reservoir characteristics of both the Thermalito Diversion Pool and Thermalito Forebay were described using existing information. Physical reservoir characteristics described included reservoir surface area, volume, morphometry, and substrate. Water temperature and water quality data were collected and summarized from SP-W1, and SP-W6 (DWR 2003).

The objective of Task 3C was to describe project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay, and to provide baseline information for use in future evaluations and development of potential Resource Actions. Project operations identified in SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat Within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, as having the potential to affect fish habitat included pumpback operations, power generating operations, and water temperature control operations to meet Feather River Fish Hatchery and downstream water temperature regulatory requirements. Pumpback operations, power generation operations, and operations designed to meet hatchery and downstream water temperature objectives were characterized and summarized from existing DWR reservoir and hatchery operations records. The analysis of how these operations influenced fish habitat components (i.e., water temperature and water level fluctuations) in the Thermalito Diversion Pool and Thermalito Forebay was designed to be a qualitative, conceptual, descriptive narrative, which would provide a baseline characterization of operations influencing these reservoirs, and was based on information in existing operational guidelines and DWR operations records. The effect of pumpback operations and power generation on water temperatures was described using data collected for SP-E8 and SP-W6, respectively (DWR 2003).

Tasks 3B and 3C of SP-F3.1 were combined because each task required the analysis of similar data and described the same geographic locations and project facilities. Data provided by SP-E8, SP-W1, and SP-W6 were compared to reported water temperature requirements and tolerance ranges for fish species currently stocked in the Thermalito Forebay to determine whether pumpback operations generally resulted in water temperature regimes that supported those fish species. Therefore, an analysis of fish habitat and project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay was necessary to provide the tools to determine whether Resource Actions affecting either reservoir would be feasible or beneficial (DWR 2003).

The habitat analyses presented in this report were based on data collected from 4/02/02 through 3/03/03 from water quality profile stations and transects in the Thermalito Forebay, and on data collected from 4/03/02 through 9/23/03 from water quality stations in the Thermalito Diversion Pool. In addition, because the FRFH receives water from the Thermalito Diversion Pool, the FRFH Annual Draft Water Temperature Report

summaries from July 1998 through June 2003 were reviewed and analyzed for compliance with monthly water temperature objectives. Furthermore, project operations during periods for which water temperature data were available were reviewed and analyzed to assess their influence on habitat conditions within the Thermalito Diversion Pool and Thermalito Forebay.

Generally, project operations were observed to have a relatively minor influence on fish habitat within the forebay and diversion pool. Therefore, continued operation of the Thermalito Complex facilities in a manner consistent with current operations would be expected to result in available habitat to support continued stocking programs in the Thermalito Forebay.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities influences water temperatures and surface elevation fluctuations in the Thermalito Diversion Pool and Thermalito Forebay. Water temperature and surface elevation are important factors influencing the availability of fish habitat in these reservoirs. As a component of study plan SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat Within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area,* Task 3 of SP-F3.1 describes fish species composition, fish habitat characteristics, and project operations influencing the Thermalito Diversion Pool and Thermalito Forebay. Task 3B and 3C, herein, characterize fish habitat in the Thermalito Diversion Pool and Thermalito Forebay, as well as describe project operations influencing the Thermalito Diversion Pool and Thermalito Forebay.

1.1.1 Statutory/Regulatory Requirements

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact from on-going and future operations.

This task is additionally related to the FERC Relicensing of the Oroville Facilities because FERC has a long history of fish stocking in Lake Oroville and the Thermalito Forebay. In 1977, FERC approved the California Department of Water Resources' (DWR) Oroville Facilities Recreation plan titled Bulletin No. 117-6 (Oroville Reservoir, Thermalito Forebay, and Thermalito Afterbay Water Resources Recreation Report), which provided plans for public utilization of project lands and waters for recreational purposes through the year 2017 (FERC 1994).

As a subtask of SP-F 3.1, Task 3B and 3C fulfills a portion of the FERC application requirements and provides documentation to support future implementation of Bulletin No. 117-6 by characterizing fish habitat in the Thermalito Diversion Pool and Thermalito Forebay and describing project operations influencing the Thermalito Diversion Pool and Thermalito Forebay.

1.1.2 Study Area

The study area in which the results of Task 3B and 3C of SP-F3.1 apply are the Thermalito Diversion Pool, the Thermalito Forebay, and the Feather River Fish Hatchery (FRFH), which receives water from the Thermalito Diversion Pool.

1.1.2.1 Description

The Thermalito Diversion Pool is an approximately 270 acre, steep-sided, narrow, riverine reservoir with low surface area-to-volume ratio and minor water surface elevation fluctuations (DWR 2001; DWR 2002b). The Thermalito Diversion Pool is supplied with cold water from Lake Oroville's hypolimnion in order to meet water temperature requirements at the Feather River Fish Hatchery and at Robinson Riffle in the main channel of the lower Feather River. As a result of the primarily cold water habitat, the Thermalito Diversion Pool fishery is dominated by cold water salmonids including rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and Chinook salmon (*O. tshawytscha*) (DWR 2001; DWR 2002b). Although the Thermalito Diversion Pool is not currently stocked, a lack of barriers between the Thermalito Diversion Pool and Thermalito Forebay allows fish stocked in the Thermalito Forebay to migrate freely into the Thermalito Diversion Pool (DWR 2001; DWR 2002b). Wakasagi (*Hypomesus nipponensis*) entrained in the Thermalito Diversion Pool from effluent from the Edward Hyatt Power Plant at the base of the Oroville Dam contribute to the existing food web in the diversion pool, resulting in an abundant forage base for salmonids (DWR 2001).

The Thermalito Forebay is an open, cold, shallow reservoir with a high surface area-to-volume ratio with few water surface elevation fluctuations (DWR 2001; DWR 2002b). Because of the cool water temperatures, the Thermalito Forebay provides habitat primarily for coldwater fish (DWR 2001; DWR 2002b). The California Department of Fish and Game (DFG) manages the Thermalito Forebay as a put-and-take trout fishery, where rainbow trout and brook trout of approximately ½ pound are stocked biweekly (DWR 2001; DWR 2002b). Surplus inland Chinook salmon from Lake Oroville stocking efforts also have been stocked in the Thermalito Forebay in February of 2000 (DWR 2001; DWR 2002b). The Thermalito Forebay is the second most popular reservoir sport fishery of the Oroville Facilities (DWR 2001; DWR 2002b).

For the purpose of this report, the Thermalito Forebay and Thermalito Diversion Pool will be considered together because they are connected by the Thermalito Power Canal and fish can move freely from one water body to another, they both provide primarily cold water habitat, and they both are affected by project operations in similar ways.

1.1.2.2 History

Minimum flows in the lower Feather River were established in an agreement between DWR and DFG signed in August 1983 (DWR 1983). The agreement established criteria for flow and water temperature in the lower Feather River. The agreement specified that DWR release a minimum of 600 cubic feet per second (cfs) into the Feather River from the Thermalito Diversion Dam for fisheries purposes. Therefore, the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet is operated at approximately 600 cfs year-round, with variations in flow occurring infrequently. Most flow deviations from 600 cfs occur during flood control releases, in the summer to satisfy downstream water temperature requirements for salmonids, or for maintenance and monitoring purposes. Water temperatures in the LFC of the lower Feather River are typically lower than those in the HFC, because the upstream reach of the Feather River is supplied directly by water taken from Lake Oroville's hypolimnion in order to meet FRFH and other downstream water temperature requirements (DWR 2001). Additionally, water temperature objectives for the FRFH were established in 1983 agreement between DWR and DFG (DWR 1983).

Feather River Fish Hatchery Water Temperature Requirements

The Thermalito Diversion Pool provides the water supply for the FRFH. The hatchery objectives specified in the 1983 agreement are 11.1°C (52°F) during September, 10.5°C (51°F) during October and November, 12.7°C (55°F) from December through March, 10.5°C (51°F) from April through May 15, 12.7°C (55°F) during the last half of May, 13.3°C (56°F) from June 1 through June 15, 15.5°C (60°F) from June 16 through August 15, and 14.4°C (58°F) from August 16 through August 31. A water temperature deviation of plus or minus 4°F from objectives is allowed by the 1983 agreement from April through November (DWR 1994; DWR 2001). The FRFH average water temperature summaries for the period from July 1998 through June 2003 obtained from the Draft Annual Reports published by DFG are presented in Table 1.1-1 (Kastner 1999; Kastner 2000; Kastner 2001; Kastner 2002; Kastner 2003).

Table 1.1-1. Average monthly water temperatures (°F) at the Feather River Fish Hatchery.

Date	Minimum Water Temperature	Maximum Water Temperature	Mean Water Temperature
July 1-31/1998	57	61	60
August 1-31/98	54	59	57
September 1-30/98	50	56	52
October 1-31/98	48	52	50
November 1-30/98	48	50	49
December 1-31/98	46	50	48
January 1-31/99	45	47	46
February 1-28/99	44	46	45
March 1-31/99	44	47	45
April 1-30/99	46	51	49
May 1-31/99	49	55	50
June 1-30/99	52	57	55
July 1-31/1999	55	59	57
August 1-31/99	54	60	56
September 1-30/99	50	56	52
October 1-31/99	49	53	52
November 1-30/99	50	52	51
December 1-31/99	50	51	51
January 1-31/00	48	50	49
February 1-28/00	46	49	47
March 1-31/00	46	48	47
April 1-30/00	48	53	52
May 1-31/00	52	55	54
June 1-30/00	54	58	55

Date	Minimum Water Temperature	Maximum Water Temperature	Mean Water Temperature
July 1-31/00	58	62	60.2
August 1-31/00	57	62	59.7
September 1-30/00	50	55	52.6
October 1-31/00	50	53	51.1
November 1-30/00	52	53	52.6
December 1-31/00	49	54	51.1
January 1-31/01	46	53	48.0
February 1-28/01	46	48	46.9
March 1-31/01	48	53	48.3
April 1-30/01	49	53	49.5
May 1-31/01	53	54	50.8
June 1-30/01	57	59	55.1
July 1-31/01	57	60	58.0
August 1-31/01	53	60	57.6
September 1-30/01	52	55	53.3
October 1-31/01	52	59	55.1
November 1-30/01	54	59	56.5
December 1-31/01	50	56	52.4
January 1-31/02	46	49	48.0
February 1-28/02	46	48	46.9
March 1-31/02	48	53	48.3
April 1-30/02	49	53	49.5
May 1-31/02	53	54	50.8
June 1-30/02	57	59	55.1
July 1-31/0	Not Provided	60	58.0
August 1-31/0	Not Provided	60	57.6
September 1-30/01	Not Provided	55	53.3
October 1-31/02	52	57	55.4
November 1-30/02	53	56	54.8
December 1-31/02	48	55	51.5
January 1-31/03	47	48	47.4
February 1-28/03	46	48	47.1
March 1-31/03	47	54	49.0
April 1-30/03	49	54	51.1
May 1-31/03	49	55	51.4
June 1-30/03	55	59	56.7

** All water temperatures are presented in degrees Fahrenheit*

Summary of Salmonid Stocking in Lake Oroville

Since 1968 DFG has stocked a variety of salmonids in Lake Oroville. From 1968 to 1978, rainbow trout, brown trout, coho salmon (*Oncorhynchus kisutch*), and kokanee salmon (*O. nerka*) were the principally stocked salmonids (DWR 1999). Beginning in 1979, coho and kokanee salmon were no longer stocked, and Chinook salmon were stocked as a substitute (DWR 1999; DWR 2001). After 1988, rainbow trout were no longer stocked (DWR 1999). From 1988 to 2000, brown trout and Chinook salmon were the principally stocked salmonids in Lake Oroville (DWR 1999). From 1990-2000, the Lake Oroville cold water fishery was managed for Chinook salmon and brown trout (DWR 1999).

Recent disease concerns, including the prevalence of infectious hematopoietic necrosis virus (IHN) in the Feather River drainage, have prompted changes in the stocking procedures at Lake Oroville. Due to their susceptibility to IHN, Chinook salmon and brown trout are not currently being stocked. Coho salmon were stocked as a replacement for Chinook salmon and brown trout in order to maintain an attractive cold water fishery in Lake Oroville, because coho salmon appear to be more resistant to IHN than other salmonid species (pers. com., E. See, DWR, 2003a). Oroville Hatchery brood stock are selectively bred for the hatchery environment, to be resistant to disease, and can withstand higher water temperatures than wild coho salmon (pers. com., E. See, DWR, 2003b). In addition, *Ceratomyxa shasta*, a myxozoan parasite that causes ceratomyxosis and is lethal to most strains of rainbow trout, is prevalent in Lake Oroville (DWR 2001). The parasite has a complex life cycle, which includes a common freshwater polychaete worm, *Manayunkia speciosa*, as an alternate host (pers. com., E. See, DWR, 2003a). The worm host may thrive in the fine sediments found in impoundments and depositional stream zones. It has been reported that the progression of ceratomyxosis is influenced by water temperature and that mortality increases in salmonids as water temperatures increase above 10°C (50°F), although it has been documented in some drainages to be infective at water temperatures below 6.1°C (43°F) (DWR 2002a).

<u>Summary of Salmonid Stocking in the Thermalito Forebay 1981-2001</u>

A variety of salmonids have been stocked in the Thermalito Forebay since 1981. In the years between 1981 and 2001, except 1996 in which no salmonids were released, records show that DFG stocked the Thermalito Forebay with a total of 1,016,853 individual salmonids. Of the total number of salmonids stocked in the forebay, 898,355 (88.3 %) were rainbow trout, 91,140 (9.0 %) were brook trout, 16,000 (1.6 %) were Eagle Lake rainbow trout, and 7,400 (0.7 %) were brown trout. Another 933 (<0.1 %) were Pit River strain rainbow trout brood stock and 3,025 (0.3 %) were Chinook salmon (pers. com., E. See, DWR, 2003b).

DFG released rainbow trout into the Thermalito Forebay every year from 1981 through 2001 except for 1996, when no salmonids were released. The highest number of rainbow trout released in a single year was 127,435 in 1987. The lowest number of rainbow trout released in a single year was 18,380 in 1998. Brook trout releases began with 14,640 fish in 1993, which was the highest number introduced in a single year, and continued in 1994. Releases of brook trout were interrupted from 1995 through 1996 and resumed from 1997 through 2001. The lowest number of brook trout released was 5,760 in 1994 (pers. com., E. See, DWR, 2003b). Rainbow trout and brook trout are the only species that have been stocked in the forebay since 1993 (DWR et al. 2003; pers. com., E. See, 2003b).

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville

Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

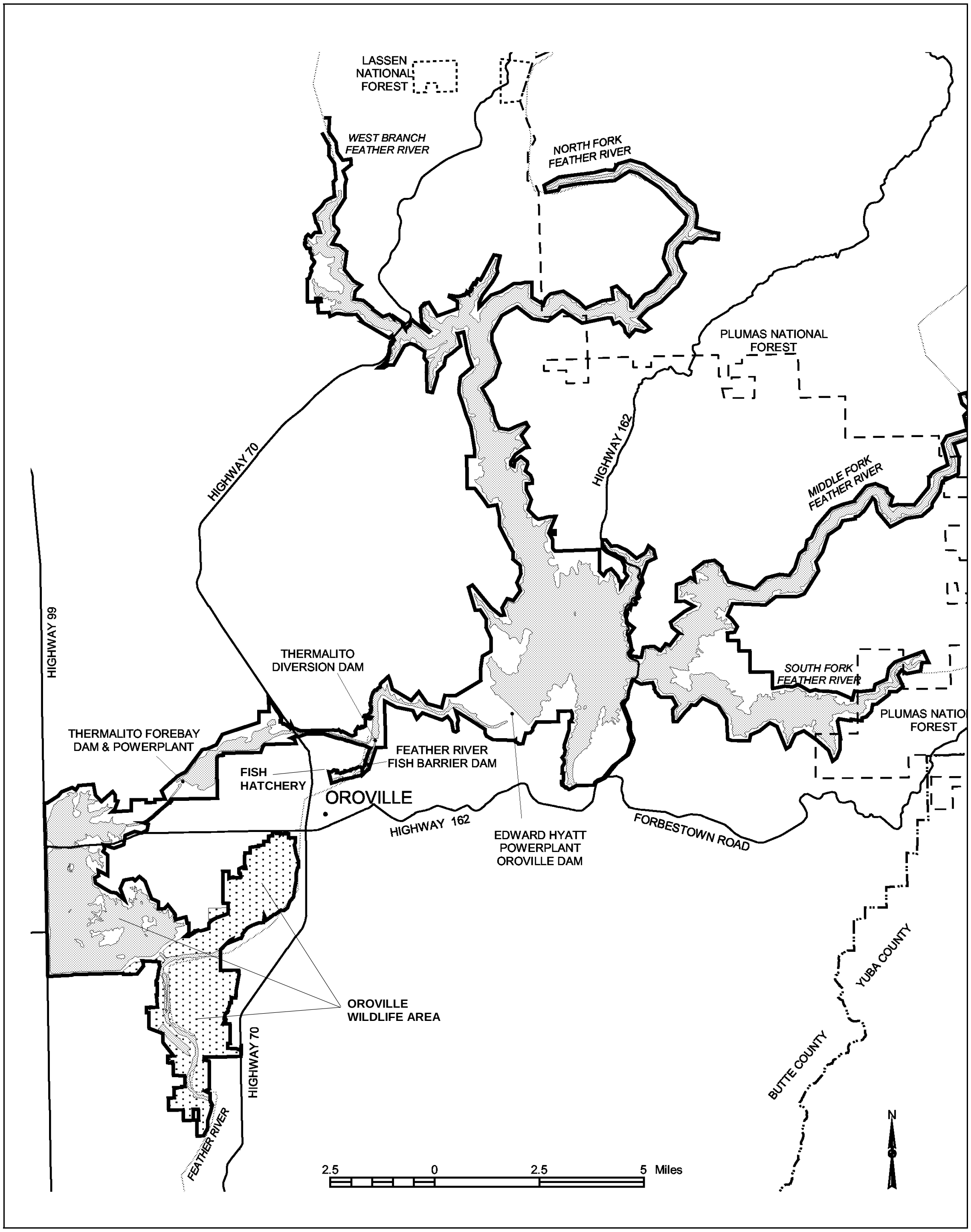

Figure 1.2-1. Oroville Facilities FERC project boundary.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the FRFH. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000 acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000-acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the SWP for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the FRFH pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Water Temperature Requirements

The Diversion Pool provides the water supply for the FRFH. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 af (July 2002) are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from the DWR water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram, or the emergency spillway release diagram, prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

As a subtask of SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, Tasks 3B and 3C fulfill a portion of the FERC application requirements by characterizing fish habitat in the Thermalito Diversion Pool and Thermalito Forebay, and by describing project operations influencing the Thermalito Diversion Pool and Thermalito Forebay. In addition to fulfilling statutory requirements, the conclusions from this analysis may be used as the basis for developing or evaluating potential Resource Actions focused on providing appropriate water temperature regimes in the Thermalito Diversion Pool and Thermalito Forebay for management of a cold water fishery.

Performing these subtasks is necessary, in part, because operations of the Oroville Facilities affect surface elevation fluctuations in the Thermalito Diversion Pool and Thermalito Forebay and directly impact and influence in-river and in-reservoir water temperature regimes (DWR 2001). Because water temperature and surface elevation are important factors influencing the availability of fish habitat, Tasks 3B and 3C of SP-F3.1 evaluate potential project effects on habitat available to coldwater fish species in these reservoirs.

3.0 STUDY OBJECTIVES

3.1 STUDY APPLICATION

The objective of Task 3B was to generally describe fish habitat in the Thermalito Diversion Pool and Thermalito Forebay. The objective of Task 3C was to describe project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay. Additionally, an analysis of fish habitat and project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay was necessary to provide the tools to determine whether potential Resource Actions would be feasible or beneficial (DWR 2003).

3.1.1 Department of Water Resources

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to determine the project effects on the quality of habitat in the Thermalito Diversion Pool and Thermalito Forebay.

4.0 METHODOLOGY

4.1 STUDY DESIGN

Task 3B of SP-F3.1 is specifically designed to evaluate fish habitat in the Thermalito Diversion Pool and Thermalito Forebay utilizing data from other FERC study plans. Task 3C of SP-F3.1 is deigned to describe the project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay, and to provide baseline information for use in future evaluations and development of potential Resource Actions.

4.1.1 Analytical Approach

Rainbow trout and brook trout were selected as the species for which thermal tolerance values would be analyzed because these species reportedly have the narrowest thermal tolerance ranges and lowest critical thermal maxima of the salmonids stocked in the Thermalito Forebay since 1993 (EPA 2002). The dissolved oxygen concentration criterion chosen as the minimum to which salmonids could be exposed was 6.5 mg/L, and was based on the EPA (2002) criterion for protection of aquatic life for growth of adult and juvenile salmonids (EPA 2002).

The analyses consisted of comparing water temperatures and dissolved oxygen concentrations reported as suitable for rainbow trout and brook trout, with the water temperatures and dissolved oxygen concentrations observed in the Thermalito Diversion Pool and Thermalito Forebay during the sampling periods.

4.1.2 Rationale For Selection of Water Temperature Indices

Task 3C of SP-F 3.1 was specifically designed to evaluate and describe project operations that influence fish habitat in the Thermalito Diversion Pool and Thermalito Forebay. Project operations characterized included pumpback operations, power-generating operations, and water temperature control operations implemented to meet FRFH and downstream water temperature requirements. Data pertaining to these operating conditions were collected and summarized from existing DWR reservoir and hatchery operations records. The description of how operations influenced habitat components (i.e., water temperature and water level fluctuations in the Thermalito Diversion Pool and Thermalito Forebay) was designed to be a qualitative, conceptual, descriptive narrative which provided a baseline characterization of operations influencing these reservoirs, and was based on information in existing operational guidelines and DWR operations records (DWR 2003). In addition, water quality data collected during pumpback operations and throughout the year in the Thermalito Forebay and the Thermalito Diversion Pool were compared to water temperature requirements and tolerance ranges for fish species currently stocked in the forebay. The comparison was used to determine whether power generation or pumpback operations resulted in water temperature regimes that provided suitable habitat for those fish species (DWR 2003).

The water temperature index values chosen for this analysis were based on the most protective EPA criteria recommended for the protection of aquatic life. The dissolved oxygen criteria index values chosen were those indicated by EPA to be appropriate for growth of juvenile and adult salmonids (EPA 2002). Additionally, the water temperature and dissolved oxygen criteria published by EPA that were chosen for this analysis were based on the management goals associated with a coldwater put-and-take fishery in the Thermalito Forebay and the Thermalito Diversion Pool, and were based on the weekly maximum average water temperature to which rainbow trout and brook trout could be exposed while meeting those management goals. EPA (2002) suggests that the maximum weekly average water temperature for growth of juvenile and adult rainbow trout and brook trout is 19°C (66.2°F) (EPA 2002). The short term maximum water temperature to which rainbow trout and brook trout could be exposed and survive is 24°C (75.2°F) (EPA 2002). Rainbow trout and brook trout were chosen as index species with respect to water temperature tolerance because they represent approximately 98% of the total fish historically stocked in Thermalito Forebay, including Pit River strain rainbow trout brood stock and Eagle Lake rainbow trout. In addition, rainbow trout and brook trout are the only species that have been stocked in the forebay since 1993, and are the only species considered abundant by DWR biologists (DWR et al. 2003; pers. com., E. See, 2003b).

Although brown trout reportedly have a lower maximum weekly average thermal tolerance than brown trout or rainbow trout, brown trout were not chosen as the index species on which to base the habitat analyses for the Thermalito Forebay and Thermalito Diversion Pool because brown trout historically accounted for less than one percent of the total fish stocked in the forebay, and had not been stocked since before 1993.

EPA's dissolved oxygen concentration criterion for a 30-day minimum exposure (6.5 mg/L dissolved oxygen) was chosen because it was the most stringent recommended EPA criterion for the protection of aquatic life while maintaining growth of adult and juvenile salmonids. Because dissolved oxygen concentration was not expected to a limiting factor in habitat availability, and because the most stringent dissolved oxygen criterion was chosen to analyze actual dissolved oxygen concentrations, it was not necessary to choose criteria for juvenile salmonid growth and survival separately.

Limnological profiles showing water temperatures and dissolved oxygen concentrations concurrently by depth were utilized to provide the foundation for the analysis of habitat suitability in the Thermalito Diversion Pool and Thermalito Forebay. A detailed description of the analysis is provided below.

4.1.3 Definition of Cold Water Habitat

The analytical approach for the analysis of usable coldwater salmonid habitat utilized physiochemical characteristics measured in the Thermalito Diversion Pool and Thermalito Forebay. Usable coldwater habitat was considered the zone of water within the Thermalito Diversion Pool and Thermalito Forebay that meets the physiochemical requirements for coldwater fish habitat. Because Task 3B focused on describing general fish habitat in the Thermalito Diversion Pool and Thermalito Forebay and Task 3C focused on describing project operations influencing the Thermalito Diversion Pool and the Thermalito Forebay (i.e., the effects of pump-back and power generation on habitat and the availability of sufficient coldwater to support salmonid stocking for a put-and-take sport fishery), and because dissolved oxygen concentrations are related to thermal stratification, both water temperature and dissolved oxygen indices were used to define the usable coldwater salmonid habitat for this analysis. Adequate dissolved oxygen concentrations and water temperatures are essential components of usable habitat because they are the physiochemical variables for which salmonids reportedly exhibit a relatively narrow and specified tolerance range (EPA 2002). Water temperature and dissolved oxygen concentration were considered concurrently because it is possible that water temperature may be appropriate for salmonid utilization at a specific depth, but that dissolved oxygen concentrations may not be appropriate for salmonids at the same depth. Considering only water temperature may have resulted in calculating usable habitat that, while appropriate for salmonids with respect to thermal tolerance, may not have been appropriate for salmonids when dissolved oxygen concentrations were additionally considered and vice versa. Therefore, both water temperature and dissolved oxygen were used to define the usable cold water salmonid habitat in the Thermalito Diversion Pool and Thermalito Forebay and to asses the effect of project operations on these water bodies.

To determine the availability of coldwater habitat for a put-and-take salmonid fishery, the water temperature at which lethality occurs was chosen as an index to represent the upper limit of potentially suitable water temperatures. The EPA updated its 1986 water quality criteria in 2002 and reports that the maximum weekly average water temperatures to which rainbow trout and brook trout can be exposed and grow and survive are 19°C (66.2°F) and 24°C (75.2°F), respectively (Table 11, Page 333) (EPA 1986; EPA 2002). Because water temperatures 19°C (66.2°F) or below are reportedly suitable for rainbow trout and brook trout growth and water temperatures 24°C (75.2°F) or below are reportedly suitable for short-term survival of those species, the water temperature range chosen to indicate habitat suitability index values for a put-and-take fishery was 19.1°C to 24°C (66.2 to 75.2°F). Additionally, because water temperatures 19°C or below are reportedly suitable for rainbow trout and brook trout growth, it was assumed that those water temperatures also would be suitable for a put-and-take fishery. Average weekly water temperatures higher than 24°C (75.2°F) were considered in excess of the suitability index for a put-and-take fishery for both rainbow trout and brook trout. Additional detail regarding application of these criteria to assess the usable coldwater habitat is presented in section 4.2.4 below.

4.2 DATA COLLECTION

Water temperatures and dissolved oxygen concentrations were collected from two transects and five point profile locations in the Thermalito Forebay and Thermalito Diversion Pool. Additionally, water temperatures were obtained from three thermographs in the Thermalito Diversion Pool. Data were generally collected between Spring 2002 and Spring 2003. Water temperature data were reported in °C and dissolved oxygen concentration data were reported in mg/L.

4.2.1 Sampling Locations and Period of Record

Data utilized in this analysis were collected from two transects and two point profiles in the Thermalito Forebay, and three point profiles and three thermographs in the Thermalito Diversion Pool (pers. com., M. Hendrick, 2003).

4.2.1.1 Thermalito Forebay

Water temperature data and dissolved oxygen concentration data were collected at two point locations within the Thermalito Forebay (labeled "N Forebay" and "S Forebay" in Figure 4.2-1) between 4/02/02 and 1/14/03. Additionally, water temperature and dissolved oxygen concentration data were colleted from two transects in the Thermalito Forebay (labeled "North Transect" and "South Transect" in Figure 4.2-1) between 5/09/02 and 3/03/03.

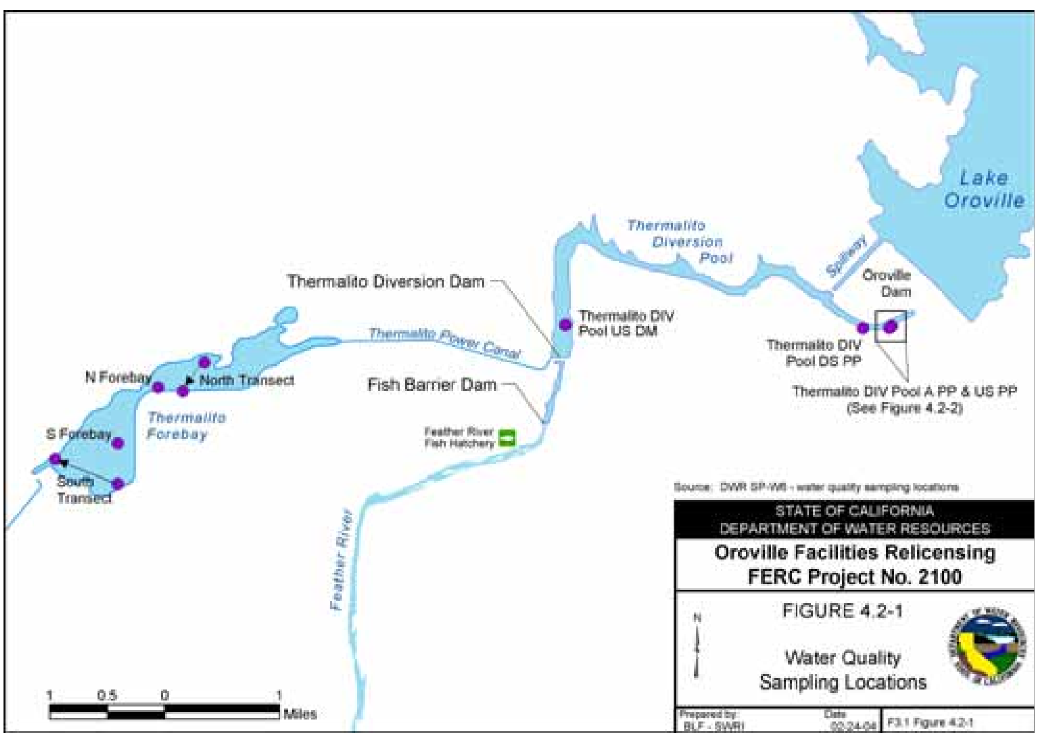

Figure 4.2-1. Forebay and diversion pool water quality sampling locations.

4.2.1.2 Thermalito Diversion Pool

Water temperature and dissolved oxygen concentration data were collected at three point profile locations within the Thermalito Diversion Pool. Additionally, three thermographs collected water temperature data at 15-minute intervals within the diversion pool. Water temperature and dissolved oxygen concentration data were collected at a sampling point located immediately downstream from the Edward Hyatt Power Plant in the diversion pool (labeled “Thermalito DIV Pool DS PP” in Figure 4.2-1 and Figure 4.2-2) between 4/03/02 and 4/14/03. A thermograph at the same location collected water temperature data at fifteen-minute intervals at the bottom of the diversion pool from 1/07/03 through 9/23/03. Water temperature and dissolved oxygen concentration data were collected at a sampling location immediately upstream from the Edward Hyatt Power Plant (labeled “Thermalito DIV Pool US PP” on Figure 4.2-1 and Figure 4.2-2) between 4/03/02 and 4/14/03. A thermograph at the same location collected water temperature data at fifteen-minute intervals at the bottom of the diversion pool from 1/07/03 through 9/23/03. Water temperature and dissolved oxygen concentration data were collected immediately upstream from the Thermalito Diversion Dam (labeled “Thermalito DIV Pool US DM” on Figure 4.2-1) between 4/03/02 and 8/26/03. Additionally, a thermograph recorded water temperatures every fifteen minutes at the bottom of the diversion pool near the Edward Hyatt Power Plant (labeled “Thermalito DIV Pool A PP” on Figure 4.2-1 and Figure 4.2-2) between 7/03/02 and 9/24/02; 12/06/02 and 4/14/03; 9/05/03 and 9/23/03 (pers. com., M. Hendrick, 2003).

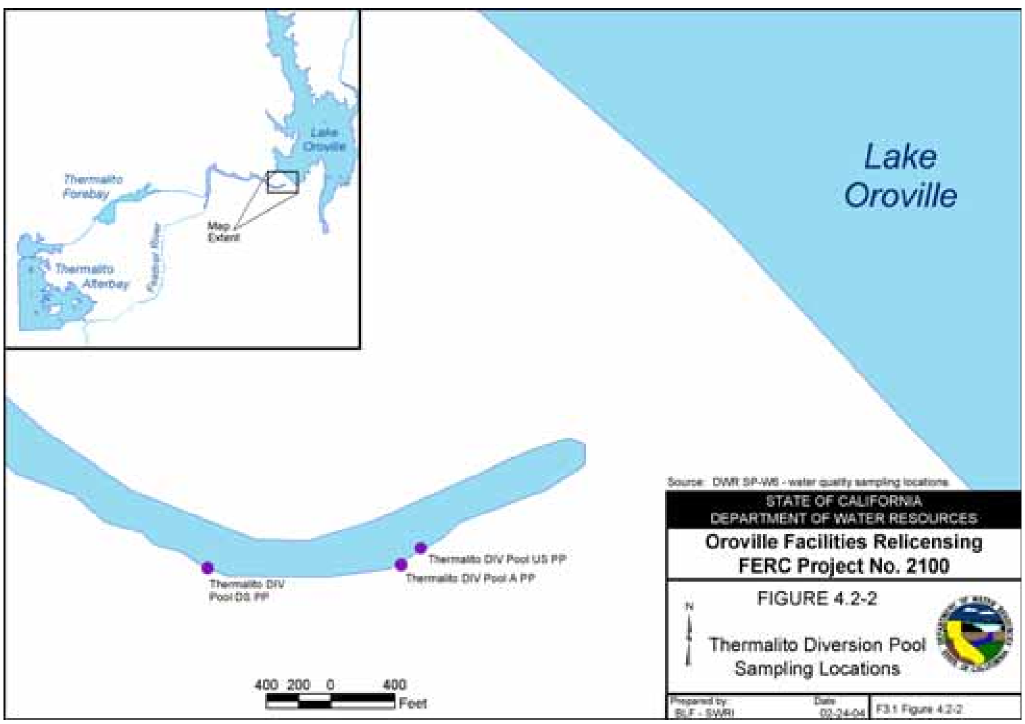

Figure 4.2-2. Thermalito Diversion pool water quality sampling locations.

4.2.1.3 GPS Locations

Global Positioning Satellite (GPS) locations of each of the transect endpoints in the Thermalito Forebay and each of the point profile locations in the forebay and diversion pool are presented in Table 4.2.1. Additionally, the GPS location of the thermograph located near the Edward Hyatt Power Plant in the Thermalito Diversion Pool (Thermalito DIV Pool A PP) is provided. It should be reiterated that the point profile locations named “Thermalito DIV Pool DS PP,” “Thermalito DIV Pool US PP,” and “Thermalito DIV Pool US DM” within the diversion pool also were associated with thermographs.

Table 4.2-1. Global Positioning Satellite coordinates of transect termini and point profile locations.

Station Location	Station Type	Station Name	Latitude	Longitude	Sample Dates
Thermalito Forebay	Transect Beginning	North Transect	N 39 31’ 44.2”	W 121 36’ 09.6”	5/09/02 - 3/03/03
Thermalito Forebay	Transect End	North Transect	N 39 31’ 31.6”	W 121 36’ 22.7”	5/09/02 - 3/03/03
Thermalito Forebay	Transect Beginning	South Transect	N 39 31’ 1.1”	W 121 37’ 38.0”	5/09/02 - 3/03/03
Thermalito Forebay	Transect End	South Transect	N 39 30’ 49.8”	W 121 37’ 1.4”	5/09/02 - 3/03/03
Thermalito Forebay	Point Profile	N Forebay	N 39 31’ 33.4”	W 121 36’ 37.1”	4/02/02 - 1/14/03
Thermalito Forebay	Point Profile	S Forebay	N 39 31’ 0.8”	W 121 37’ 1.2”	4/02/02 - 1/14/03
Thermalito Diversion Pool	Point Profile/ Thermograph	Thermalito DIV Pool DS PP	N 39 31’ 54.8”	W 121 29’ 43.3”	4/03/02 – 4/14/03 and 1/07/03 – 9/23/03
Thermalito Diversion Pool	Thermograph	Thermalito DIV Pool A PP	N 39 31’ 54.8”	W 121 29’ 27.9”	7/03/02 – 9/23/03
Thermalito Diversion Pool	Point Profile/ Thermograph	Thermalito DIV Pool US PP	N 39 31’ 55.8”	W 121 29’ 26.3”	4/03/02 – 4/14/03 and 1/07/03 – 9/23/03
Thermalito Diversion Pool	Point Profile	Thermalito DIV Pool US DM	N 39 31’ 58.6”	W 121 32’ 37.8”	4/03/02 – 8/26/03

Transect locations, point profile locations, and thermograph locations were chosen by DWR staff in an attempt to obtain an accurate representation of the conditions within the entire Thermalito Diversion Pool and Thermalito Forebay.

4.2.2 Instrumentation

DWR used three Onset water temperature recorders that were set to record water temperatures (°C) every 15 minutes at the three fixed locations near the Edward Hyatt Power Plant in the Thermalito Diversion Pool. Data were collected at the point profile locations in the diversion pool and forebay and along the transects in the forebay using a Yellow Springs Instruments (YSI) multi-parameter probe. At each of these locations DWR water quality scientists performed surface-to-bottom profiles that included collecting water temperature (°C) and dissolved oxygen concentration (mg/L) measurements. During periods of heavy water releases from Lake Oroville, surface-to-bottom profiles near the power plant were not possible, thus only surface readings were performed (pers. com., M. Hendrick, 2003).

4.2.3 Calculation of Volume of Usable Cold Water Habitat and Data Limitations

Because operating procedures for the Thermalito Diversion Pool and Thermalito Forebay are based on a variety of factors including power supply needs, it is difficult to predict surface water elevation and volume fluctuations. Although data collection efforts were similar between sampling events, fluctuations in water surface elevation and diversion pool and forebay volume as a result of normal project operations and spilling from Lake Oroville that occurred during the sampling period precluded calculation of the volume of usable cold water habitat utilizing the available data.

In addition to difficulties associated with calculating usable cold water volume, gaps in the continuity of the data exist. Thermalito Forebay transect data were not obtained for September 2002 and February 2003, although point profile location data were collected at both sampling locations during September 2002. Additionally, during times of spilling over the Oroville Dam spillway or during heavy water releases through the Edward Hyatt Power Plant over the course of the sampling period, surface to bottom profiles in the diversion pool point profile locations near the power plant were not possible (pers. com., M. Hendrick, 2003).

Changing diversion pool and forebay conditions during the sampling period that caused differences in the sampling procedures (i.e., variable profile depths due to water surface elevation fluctuations) caused some variability in the collected data. In addition, a lack of transect data in the forebay for two months (September 2002 and February 2003), and gaps in thermograph water temperature data at the diversion pool power plant (9/25/02 to 12/5/02 and 4/15/03 to 9/4/03), added complexity to the data analysis and precluded a volumetric analysis of usable cold water habitat. Moreover, the sampling periods for data collected in the diversion pool and forebay cannot be accurately compared because of differences in sampling periods, data collection methodology (transects versus profiles), and intervals at which water quality data was sampled.

Additionally, it should be noted that transects, point profile locations, and thermograph water temperature stations do not necessarily represent the entire Thermalito Forebay and Thermalito Diversion Pool. Rather, the water quality data represent the water quality of the portions these reservoirs that were sampled.

5.0 RESULTS

5.1 WATER TEMPERATURE AND DISSOLVED OXYGEN CONCENTRATION

Analysis of data for coldwater habitat availability was performed on data collected during the period from 4/03/02 to 9/23/03 in the Thermalito Diversion Pool and during the period from 4/02/02 to 3/03/03 in the Thermalito Forebay. Based on EPA (2002) published water temperature tolerance values water temperatures 19°C (66.2°F) or less were considered suitable for growth of salmonids currently inhabiting the Thermalito Forebay and Thermalito Diversion Pool. Water temperatures from 19.1°C (66.4°F) through 24°C (75.2°F) were considered unsuitable for growth, but remained sub-lethal. Therefore, water temperatures 24°C or below were considered suitable for a put-and-take coldwater salmonid fishery in the forebay and diversion pool. Water temperatures equal to or greater than 24.1°C (75.2°F) were considered beyond the suitability index range for a put-and-take coldwater fishery.

5.1.1 Thermalito Forebay

All Thermalito Forebay transect and point profile water temperatures recorded during the period of record were below 19.0°C (66.2°F), the EPA criterion for maximum weekly average water temperature for growth of juvenile and adult rainbow trout and brook trout. In addition, all dissolved oxygen concentrations exceeded 6.5 mg/L, the minimum dissolved oxygen concentration criterion chosen for this analysis to be suitable for a put-and-take coldwater fishery. Table 5.1-1 shows the extreme water temperatures and dissolved oxygen concentrations obtained from the Thermalito Forebay during the period of record.

Table 5.1-1 Extreme water temperatures and dissolved oxygen concentrations in the Thermalito Forebay during the period of record.

Station Location	Extreme	Water Temperature (°C)	Dissolved Oxygen Concentration (mg/L)
North Transect	High	15.2	10.4
North Transect	Low	8.6	8.0
South Transect	High	18.1	10.5
South Transect	Low	8.9	8.0
N Forebay	High	15	11.6
N Forebay	Low	8.8	8.4
S Forebay	High	16.3	8.5
S Forebay	Low	9.1	11.4

5.1.2 Thermalito Diversion Pool

Water temperatures for all three point profile locations in the Thermalito Diversion Pool remained below 24°C (75.2 °F) for the duration of the sampling period. Additionally, water temperatures collected from the “Thermalito DIV Pool DS PP” and “Thermalito DIV Pool US DM” point profiles never exceeded 19°C (66.2°F) during the period of record. Dissolved oxygen concentration data collected at the three point profile locations indicated that dissolved oxygen concentrations never dropped below 6.5 mg/L at any location during the sampling period. Water temperature and dissolved oxygen concentration extreme values collected from the Thermalito Diversion Pool are shown in Table 5.1-2.

Water temperature data at the point profile location “Thermalito DIV Pool US PP” indicated one exceedance of suitable EPA (2002) water temperature criteria for growth of rainbow trout and brown trout (19°C) during the period of record. However, the water temperatures recorded at this point profile location remained below 24°C (75.2 °F) for the duration of the sampling period. The water temperature on 10/24/02, at 11:00 AM, at a depth of 0.15 m below surface was 19.1°C (66.4°F). Heavy water releases from Lake Oroville precluded a full range of water temperature and dissolved oxygen data collection below 0.15 m for this location on 10/24/02. Therefore, only one water temperature value was obtained near the surface.

Water temperature data collected from the three thermographs located in the Thermalito Diversion Pool (Thermalito DIV Pool US PP, Thermalito DIV Pool DS PP, and Thermalito DIV Pool A PP) show a substantial amount of variation. For the majority of the sampling period the water temperatures collected from the thermographs in all three locations within the Thermalito Diversion Pool were below 24°C (74.2°F). Water temperatures collected by the “Thermalito DIV Pool US PP” and “Thermalito DIV Pool DS PP” thermographs remained below 19°C (66.4°F) for the duration of the sampling period.

Water temperature data collected from the “Thermalito DIV Pool A PP” thermograph ranged from a low water temperature of 6.2°C (43.2 °F) at 8:05 am on 2/6/03 to a high water temperature of 37.6°C (99.6°F) at 4:11 pm on 9/5/03. The highest weekly average water temperature obtained from the “Thermalito DIV Pool A PP” thermograph was 20.1°C (68.1°F) during the week of 9/5/03 through 9/11/03. During this week, water temperatures obtained from the thermograph ranged from 10.9°C (51.6°F) to 37.6°C (99.6°F). The highest daily average water temperature during the week of 9/5/03 through 9/11/03 was 30.4°C (86.7°F) on 9/5/03 while the lowest daily average during that week was 11.6°C (52.9°F).

From 4/03/02 through 4/14/03 dissolved oxygen was measured at the point profile locations “Thermalito DIV Pool US PP” and “Thermalito DIV Pool DS PP.” Between 4/03/02 and 8/26/03 dissolved oxygen concentrations were measured at the “Thermalito DIV Pool US DM.” The range of dissolved oxygen concentrations collected in the Thermalito Diversion Pool was between 6.9 mg/L, on 8/05/03 at depths of 7 m and 10 m below surface and 11.3 mg/L on 4/03/02 at depths of 2 m and 3 m below surface. Table 5.1-2 shows the extreme water temperatures and dissolved oxygen concentrations obtained from the Thermalito Diversion Pool during the period of record.

Table 5.1-2 Extreme water temperatures and dissolved oxygen concentrations in the Thermalito Diversion Pool during the period of record.

Station Name	Station type	Extreme	Water Temperature (°C)	Dissolved Oxygen Concentration (mg/L)
Thermalito DIV Pool US PP	Profile	High	19.1	10.8
Thermalito DIV Pool US PP	Profile	Low	8.2	8.0
Thermalito DIV Pool DS PP	Profile	High	8.4	11.0
Thermalito DIV Pool DS PP	Profile	Low	13.7	8.7
Thermalito DIV Pool US DM	Profile	High	16.2	11.3
Thermalito DIV Pool US DM	Profile	Low	8.2	6.9
Thermalito DIV Pool US PP	Thermograph	High	17.1	N/A
Thermalito DIV Pool US PP	Thermograph	Low	7.0	N/A
Thermalito DIV Pool A PP	Thermograph	High	37.6	N/A
Thermalito DIV Pool A PP	Thermograph	Low	6.2	N/A
Thermalito DIV Pool DS PP	Thermograph	High	17.1	N/A
Thermalito DIV Pool DS PP	Thermograph	Low	7.0	N/A

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Tasks 3B and 3C are subtasks of SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.* Tasks 3B and 3C fulfill a portion of the FERC application requirements by characterizing fish habitat in the Thermalito Diversion Pool and Thermalito Forebay and describing project operations influencing the Thermalito Diversion Pool and Thermalito Forebay. Additionally, data collected for these tasks could serve as a foundation for future evaluation and development of potential Resource Actions focused on providing appropriate water temperature regimes in the Thermalito Diversion Pool and Thermalito Forebay for management of a coldwater fishery.

Current operations allow water to be pumped back from the Thermalito Afterbay into the Thermalito Forebay and Thermalito Diversion Pool for reuse during power generation. In addition, potentially warmer water pumped back into the diversion pool could be released into the low flow section of the Feather River, which could affect hatchery operations and fisheries in the lower Feather River. The FRFH has water temperature objectives for each month of the year specified in 1983 DFG and DWR operations agreement. However, if water warms substantially during pump-back operations, and water in the diversion pool exceeds the hatchery water temperature objectives for that month, pump-back is curtailed.

Meeting Feather River water temperature objectives is facilitated by a shutter controlled intake gate system at the Oroville Dam intake structures that selects water for release from various Lake Oroville reservoir depths, depending on the desired water temperature (DWR 2001). However, this does not apply to water spilling over the dam during Oroville Dam spill events.

The cold water temperatures in the Thermalito Diversion Pool and Thermalito Forebay provide a less complex reservoir habitat regime than that of Lake Oroville, resulting in a noticeably smaller and less diverse fish species composition. Rainbow and brook trout are currently stocked by DFG because they perform well in cold water reservoirs, they are popular with sport anglers, and are economical to raise at state fish hatcheries (DWR et al. 2003). In addition, rainbow trout and brook trout are the only species that have been stocked in the forebay since 1993 (DWR et al. 2003; pers. com., E. See, 2003b).

6.2 PROJECT-RELATED EFFECTS

Because the life expectancy of fish stocked in the Thermalito Forebay currently is relatively short, approximately two months, no habitat enhancements have been conducted in the Thermalito Diversion Pool or Thermalito Forebay (pers. com., E. See, 2003b). The current put-and-take fishery operated by DFG has a goal of 50% of stocked fish being harvested by sport angling each month. DFG stocks the forebay with approximately half-pound rainbow and brook trout biweekly (DWR 2001; DWR 2002b). Additionally, mortality rates associated with ceratomyxosis reportedly are high (DWR et al. 2003).

Moyle (2002) reported that preferred water temperatures for growth of rainbow trout are around 15.0°C to 18.0 (59.0-64.4°F) and that they are found where daytime water temperatures range from nearly 0°C in winter to 26.0°C to 27.0°C (78.8°F to 80.6°F) in summer, although extremely low (less than 4.0°C (39.2°F)) or extremely high (greater than 23.0°C (73.4°F)) water temperatures can be lethal if fish have not previously been gradually acclimated (Moyle 2002). Brook trout reportedly are naturally found in clear, cold lakes and streams, and are among the most cold tolerant of salmonids, feeding at temperatures as low as 1.0°C (33.8°F) (Moyle 2002). Brook trout are reported to prefer water temperatures between 14°C and 19°C (57.2°F and 66.2°F) but can survive water temperatures up to 26.0°C (78.8°F) if acclimated to them. Moyle (2002) reported that growth is poor at water temperatures above 19.0°C (66.2°F), however.

Analysis of project operations shows that pump-back can result in some degree of warming during certain times of the year. However, warming associated with pump-back did not exceed the water temperature index range during the period of record for a brook trout and rainbow trout put-and take sport fishery. Although water temperatures never exceeded 24.0°C (75.2°F) in the Thermalito Forebay or Thermalito Diversion Pool transects or point profiles, project operations occasionally caused water temperatures to exceed the objectives established for the FRFH, which gets its water from the Forebay or Diversion Dam. Additionally, warmer water pumped back into the Thermalito Diversion Pool could potentially be released into the low flow section of the lower Feather River, which may affect hatchery operations and the in-river fishery (DWR 2002a). During times when the in-river fishery and hatchery operations are sensitive to water temperature changes, attempts are made by DWR to curtail pump-back from the Thermalito Afterbay to the Thermalito Forebay (pers. com., E. See, 2003a). Although pump-back may warm water in the forebay and diversion pool, water temperatures recorded at the transect or point profile locations during the study period were never above the index value of 24.0°C (75.2°F) established for a put-and-take salmonid fishery, and were rarely above 19°C (66.2°F).

Water temperatures in the Thermalito Forebay and Thermalito Diversion Pool never exceeded 19.0°C (66.2°F) during the sampling period, but for a few exceptions. One thermograph (Thermalito DIV Pool A PP) located at the bottom of the diversion pool reached 37.6°C (99.6°F) for one recording event on 9/5/03. The highest daily average water temperature during the week of 9/5/03 through 9/11/03 was 30.4°C (86.7°F) on 9/5/03 while the lowest daily average during that week was 11.6°C (52.9°F). The only daily average water temperature above 24°C (75.2°F) during that week occurred on 9/5/03. The weekly average water temperature recorded at the “Thermalito DIV Pool A

PP" thermograph for the week of 9/5/03 through 9/11/03 was 20.1°C (68.1°F), below the EPA recommended maximum water temperature for short-term survival of brook trout and rainbow trout. Therefore, although several individual water temperatures recorded every 15 minutes and one daily average water temperature was above 24°C (75.2°F), the weekly average water temperatures recorded at the "Thermalito DIV Pool A PP" thermograph were never above the index water temperature representing suitability for a put-and-take salmonid fishery.

The daily average water temperatures at the "Thermalito DIV Pool US PP" and "Thermalito DIV Pool DS PP" thermographs for 9/5/03, which was the date with the highest daily average water temperature (30.4°C) at the "Thermalito DIV Pool A PP" station, were 9.7°C (49.5°F) and 10.75°C (51.4°F), respectively. If the thermograph that recorded the daily average water temperature of 30.4°C (86.7°F) on 9/5/03 was not malfunctioning, it is likely that sufficient cold water existed elsewhere in the diversion pool on that day to allow stocked salmonids a temporary thermal refugium.

In addition to the anomalous water temperatures recorded during the week of 9/5/03 through 9/11/03 one water temperature sample recorded at the point location "Thermalito DIV Pool US PP" exceeded 19.0°C (66.2°F). The exceedance occurred on 10/24/02, at a depth of 0.15 m below the surface, with a water temperature of 19.1°C (66.4°F). The remaining water temperatures in the forebay and diversion pool all were below 19.0°C (66.2°F) for the duration of the sampling period.

The index value chosen as the minimum dissolved oxygen concentration for this study was 6.5 mg/L for a 30 day mean exposure, and was based on EPA (2002) criteria for protection of aquatic life for growth of adult and juvenile salmonids and to maintain consistency with other related study plan reports. In addition this is the strictest criterion for dissolved oxygen that is consistent with a put-and take fishery.

The lowest dissolved oxygen concentration observed during the sampling period was 6.9 mg/L in the Thermalito Diversion Pool and 8.0 mg/L in the Thermalito Forebay. Because dissolved oxygen concentrations never fell below theEPA minimum criterion for growth of adult and juvenile salmonids, it is likely that dissolved oxygen is not a limiting factor in the availability of coldwater habitat in the diversion pool or forebay. Additionally, the constant addition of oxygenated water from Lake Oroville likely assists in maintaining dissolved oxygen concentrations above 6.5 mg/L in the diversion pool and forebay.

7.0 REFERENCES

DWR. 1983. DWR & CDFG 1983 Agreement.

DWR. 1994. Lake Oroville Fisheries Management Plan 1994 Annual Report.

DWR. 1999. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improvements. FERC Project No. 2100-054.

DWR. 2001. Initial Information Package, Relicensing of the Oroville Facilities. FERC License Project No. 2100.

DWR. 2002a. SP-W6 Project Effects on Temperature Regime. Oroville Facilities Relicensing Project, FERC Project No. 2100.

DWR. 2002b. Study Plan Package Presented to the Plenary Group by the Collaborative Work Groups: Land Use, Land Management & Aesthetics, Recreation & Socioeconomics, Cultural Resources, Engineering & Operations, Environmental.

DWR. 2003. SP-F3.1 Evaluation of Project Effects on Fish and Their Habitat Within Lake Oroville, Its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area. Oroville Facilities Project Relicensing (FERC No.2001).

DWR, T. Mills, and E. See. 2003. SP-F3.1 Task 2A, 3A Report Fish Species Composition: Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay.

EPA. 1986. Ambient Water Quality Criteria for Dissolved Oxygen. EPA 440/5-86-003. Washington, D.C.: EPA, Office of Water Regulations and Standards, Criteria and Standards Division.

EPA. 2002. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047.

FERC. 1994. 68 FERC 61, 358 Order on Revised Recreation Plan.

FERC. 2001. Conservation of Power and Water Resources. 18 CFR 4.51. April 1, 2001.

Hendrick, M., Pitts, A., GPS Data for Diversion Pool- E-Mail Communication. October 27, 2003.

Kastner, A. 1999. Feather River Hatchery- Draft Annual Report 1998-1999. Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game.

Kastner, A. 2000. Feather River Hatchery- Draft Annual Report 1999-2000. Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game.

Kastner, A. 2001. Feather River Hatchery- Draft Annual Report 2000-2001. Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game.

Kastner, A. 2002. Feather River Hatchery- Draft Annual Report 2001-2002. Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game.

Kastner, A. 2003. Feather River Hatchery- Draft Annual Report 2002-2003. Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game.

Moyle, P. B.2002. Inland Fishes of California. Berkeley: University of California Press.

See, E., Hornback, J., Effect of Pumpback on Thermalito Forebay- Email Communication. June 24, 2003a.

See, E., Hornback, J., Project Operations Influencing the Thermalito Diversion Pool and Thermalito Forebay- Email Communication. June 23, 2003b.

See, E., Hornback, J, Personal Communication. May 2, 2003b.

See, E., Jim Hornback, Personal Communication. June 2, 2003a.